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# A Flare and Overpressure Management System
## Part I: Methods, Metrics, KPIs and Software Solutions

Enhancing PSM by way of Focused, Metric-Driven Management Systems…a compilation of best practices made better

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This paper identifies the attributes and benefits of a data and metrics-driven management system focused on the process safety design integrity, reliability, and control of process plant flares and pressure relief systems. This management system process focuses on the four key ***business drivers of risk, regulatory, operations, and profits***, and involves several distinct ***business methods involving people, processes and tools/technology***. At the center of the management system is the unique design and implementation of ***metrics and KPIs*** created from data lifted and aggregated from an enterprise informational management platform.

## 1. About the Current Regulatory Climate

The highly publicized incidents at BP Texas City in 2005, Tesoro Anacortes in 2010, and Chevron Richmond in 2012 all happened not due to a failure of equipment, instrumentation, facility siting, operator, procedure, communication, supervision, or training, but rather a failure of all those things together, i.e., ***a management system failure***.

The BP, Tesoro and Chevron incidents are now driving the reexamination of the PSM rule by the US regulatory community. The US Chemical Safety Board (CSB) has taken notice that ***US Oil & Gas industry losses are highest among any industrial sector, and that the US Refining industry accident rate is 3 to 4 times*** higher than in Europe.

The PSM rule and its allegedly "less rigorous regulatory framework" are quickly falling out of favor with regulators. As such, the attributes of the "Safety Case" and ALARP regulatory regime currently in use throughout the United Kingdom, Australia and Norway are now being advocated by the CSB. And even more notable is California's proposed regulation for ***inherently safer***

***design (ISD)***, an initiative which was just endorsed by CSB chairman Dr. Moure-Eraso, with him suggesting that other states should do the same.

ISD has been hotly debated for years, and would require that risk be reduced to the greatest extent possible with the selection and implementation of changes in chemistry and/or a change to process variables, e.g., reduction in pressure, temperature, flows, etc. Unmistakably, this would be taking the petrochemical industry and its PSM process safety approach ***from performance-based to prescriptive***.

Yet, before opting to prescriptively rewrite the PSM rule, I suggest that there is a performance-based option which is more sensible, productive and achievable in the short term, and that is a ***focused metrics-driven management system approach***. Such an approach also embodies the core principles of the PSM rule and is consistent with the findings and recommendations of the 2007 Baker Panel Report.

- A Review of Baker Panel Findings and Opportunities for Improvement…
    1. Process Safety Management Systems
        a. **Process risk assessment and analysis**
        b. Compliance with internal process safety standards
        c. **Implementation of industry good engineering practices** – *Engineering design practices and associated training are in place and translate industry RAGAGEP into specific 'how to' design guidance and application standards.*
        d. Process safety knowledge and competence
        e. **Effectiveness of corporate process safety management system** –*Management systems are effective and successful in preventing incidents (PSE's)*
    2. Performance Evaluation, Corrective Action, and Corporate Oversight
        a. **Measuring process safety performance**
        b. Incident and near miss investigations
        c. **Process safety audits**
        d. **Correction of identified process safety deficiencies** - *Repeat findings are addressed suggesting that 'true root causes' are being identified and corrected.*
        e. **Effective use of findings from operating experiences, process hazard analyses, audits, near misses, and incident investigations to improve operations and systems** – *Performance data and indicators are effectively used to drive continuous improvement in process safety and risk management systems (e.g., the risk of major incident relative to LOPC data…Baker Report).*
        f. Adequate management and corporate oversight
    3. Corporate Safety Culture…***Any one or all of the following management system elements might be scrutinized in the event of an incident relative to the opportunities noted above.***
        a. *Effectiveness of process safety leadership*
        b. *Adequacy of employee involvement and empowerment*
        c. *Adequacy of resources and positioning of process safety capabilities*
        d. *Effectiveness of incorporation of process safety into management decision-making*
        e. *Common, unifying process safety culture*

It would seem that the Baker Report is prompting us to revisit the PSM rule for intent and direction as well as ***the proper administration of the PSM rule***, i.e., the effective application of a

management systems approach to continuously improving our process safety environment and culture. After all, the authors of PSM took great pains to make it a performance-based standard for a reason (i.e., prescriptive is inherently inferior), so let's not give-up on that now.

## 2. Revisiting PSM, Management Systems and Continuous Improvement

With promulgation of the PSM Standard 29 CFR 1910.119, OSHA mandated that a management system comprised of several well-defined elements be established *"for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals."* The Process Safety Information (PSI) element of the PSM rule states *"the employer shall document that equipment complies with recognized and generally accepted good engineering practices (RAGAGEP),"* with specific reference given to *"relief system design and design basis."*

Although OSHA does not explicitly use the term *continuously improving* in their regulatory standards, they use equivalent terms such as *accurate, complete, clear* and *on-going.* For example, in the Appendix C compliance guidelines of 29 CFR 1910.119, OSHA uses the term *"complete and accurate"* in lieu of *"continually improving."* Likewise, for the Mechanical Integrity element of 29 CFR 1910.119, OSHA uses the term *"on-going"* to describe the expectation to continually improve.

Recent incidents and enforcement actions demonstrate OSHA's expectation for operating plants to maintain a continually improving PSM system. In 2007, OSHA initiated a special enforcement initiative (OSHA's National Emphasis Program [NEP]) specific to refineries and chemical plants. Of the citations issued, many involved missing, inaccurate and incomplete process safety information as well as outdated relief system studies.

Furthermore, flare and relief system design compliance is assessed annually in ever increasing detail for participants of OSHA's Voluntary Protection Program (VPP). ***Clearly, it is OSHA's expectation that operating plants have a continuously improving management systems process for ensuring the complete, accurate, clear and on-going integrity of design and operations of flares and relief systems.***

And, besides process safety, there is the environmental enforcement aspect to flare operation and systems management which continues to make the news…

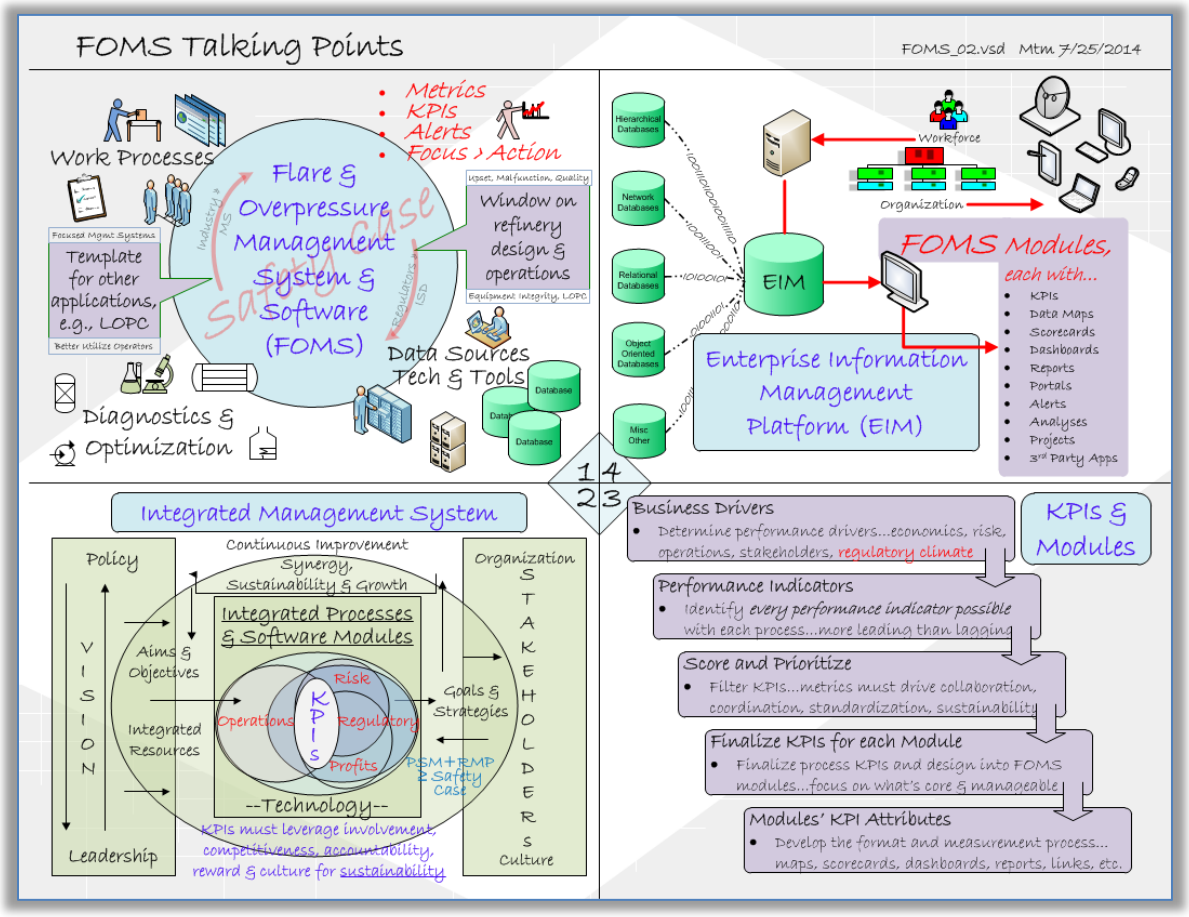
**EPA: NSPS Subpart Ja (consent decrees and penalties)**

- Equistar Chemicals – $1,900,000 (2007)
- INEOS (Lanxess) – $3,100,000 (2009)
- Marathon Petroleum – $460,000 (2012)
- BP Whiting Refinery – $8,000,000 (2012)
- Shell Deer Park - $115,000,000 (2013)

Besides, in the interest of social responsibility, it is just good business to develop a management system which not only enhances safety and environmental protection, but augments asset

protection as well. Clearly, safety and environmental stewardship are of paramount importance, but asset protection, business continuity and public image also have vital significance in any business environment.

Of course, knowing what data to capture and display is essential to proper metrics development and analysis, and the ensuing derivation of key performance indicators (KPIs). So, what follows here is the ***who, what, when, where and how*** of doing just that with a focused, metrics-driven ***flare and overpressure management system, i.e., FOMS.***

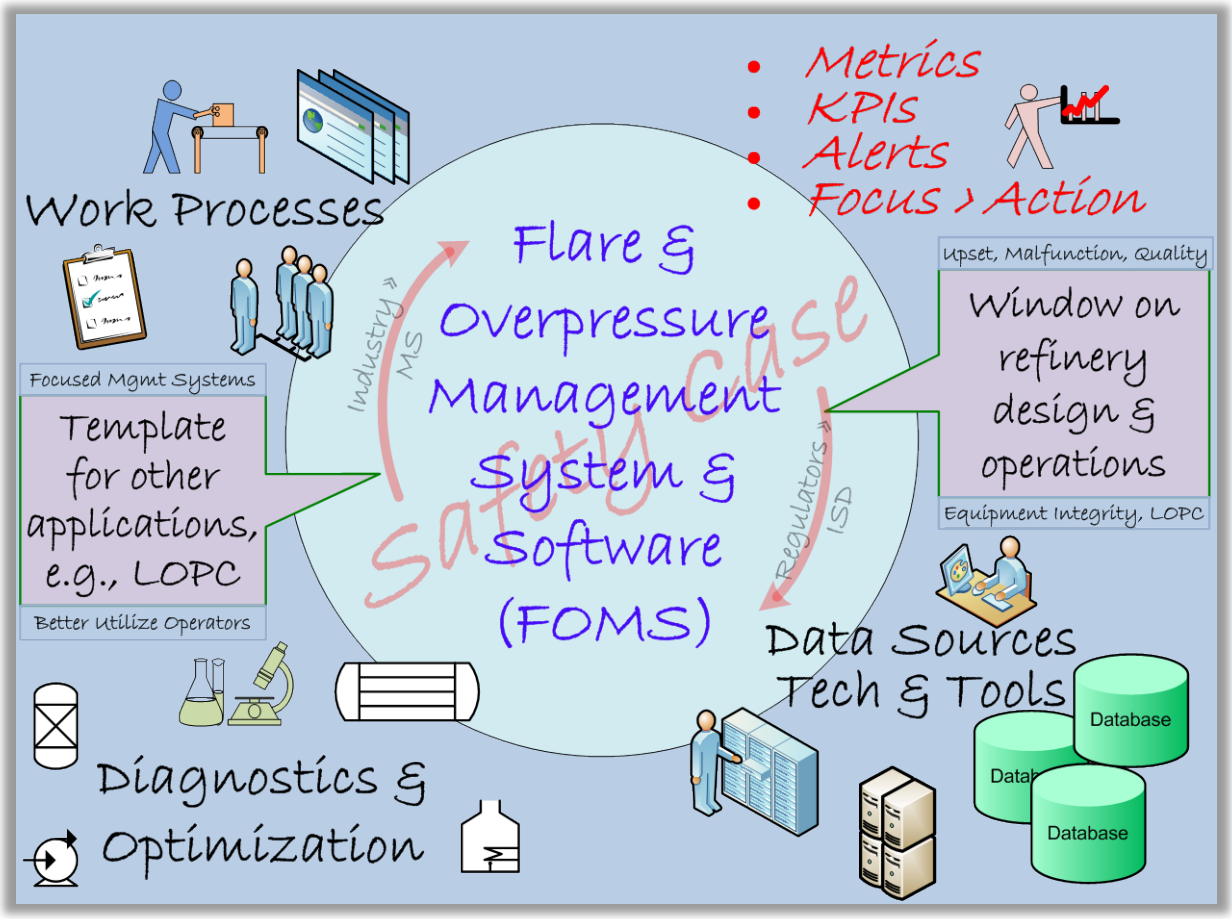



## 3. A Management System Just for Flares and Relief Systems (FOMS)

It goes without saying that flare and relief system design and operation have come under intense scrutiny by OSHA. And now with the EPA getting into the act, it would seem as though regulators are now looking for a new '3% IPD' (inlet pressure drop) style soft spot, and found it in flare system operation and management.

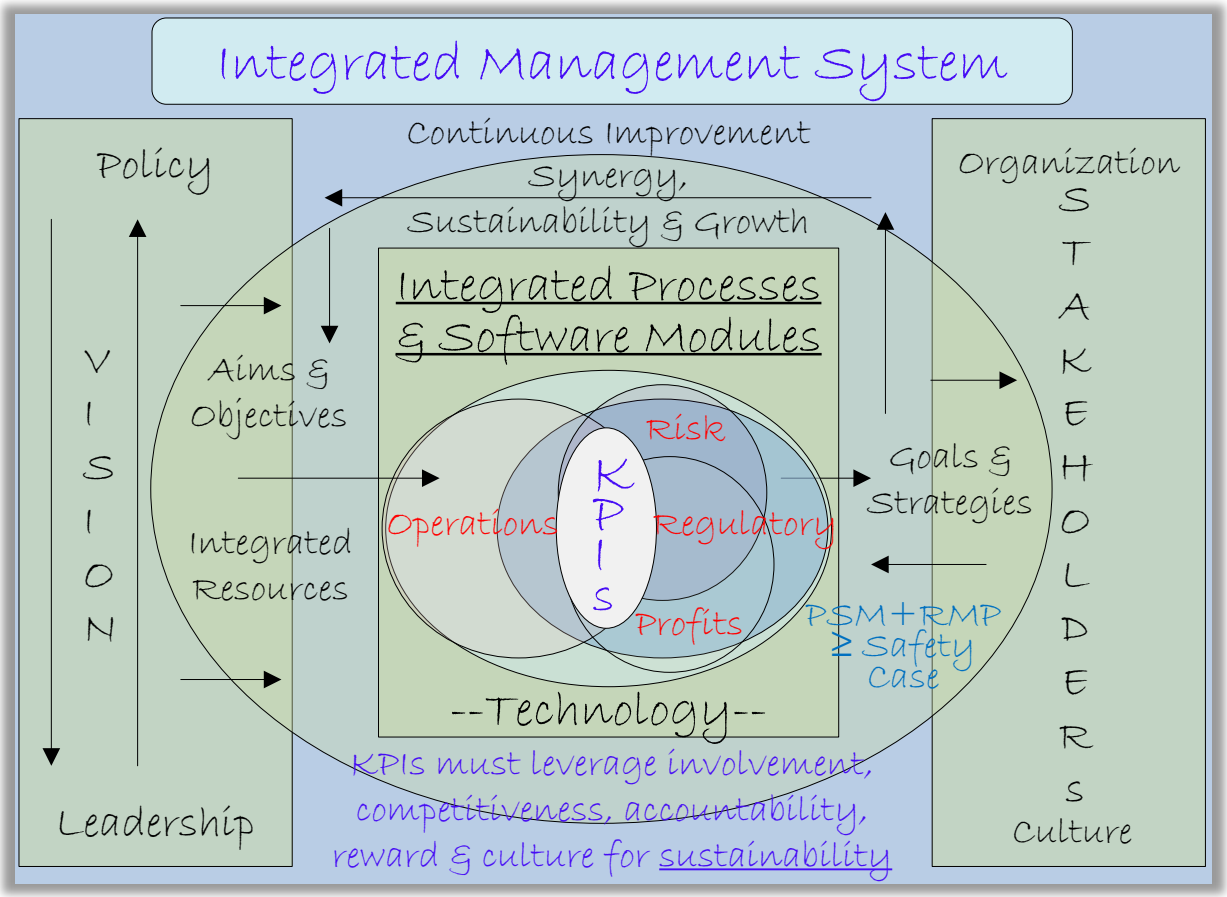
The vast majority of time, gas flaring is associated with plant upset, misoperation or imbalance, and as such is unplanned and subject to regulatory penalty. EPA is now aggressively mandating and enforcing flare management plans (FMPs) and flare gas recovery systems just like OSHA enforced relief system pressure relief analyses (PRAs) and the 3% IPD rule.

So, it is clear that this double barrel surge by way of OSHA and EPA has arrived and is progressing rapidly forward. It may seem as though industry is under assault, but the ultimate truth is that ***process safety just makes good business sense***.




When considering a performance improvement program in this highly regulated process safety environment, ***four key business drivers should first be considered, i.e., risk, regulatory, operations, and profits***. Then, building a focused flare and relief systems management process around those four drivers involves a unique ***management system structure of people, processes and tools/technology***.

Central to the growth and continuous improvement of those three elements will be the proper design and implementation of metrics and KPIs. ***It will be the institutionalization of KPIs and the subsequent reporting and action planning process which drives the continuity and sustainability of the plan-do-check-act rudiments of this management system approach.***




**4. Sustainability thru Key Performance Indicators (KPIs)**

The PSM standard is exceptional in its vision, design and implementation, but it could have been made better by the inclusion of metrics and KPIs. As is often said, ***"if it can't be measured, it can't be managed,"*** and is likely a reason why so many process safety management system programs have failed to grow and measure up to industry best practices as well as OSHA expectations.

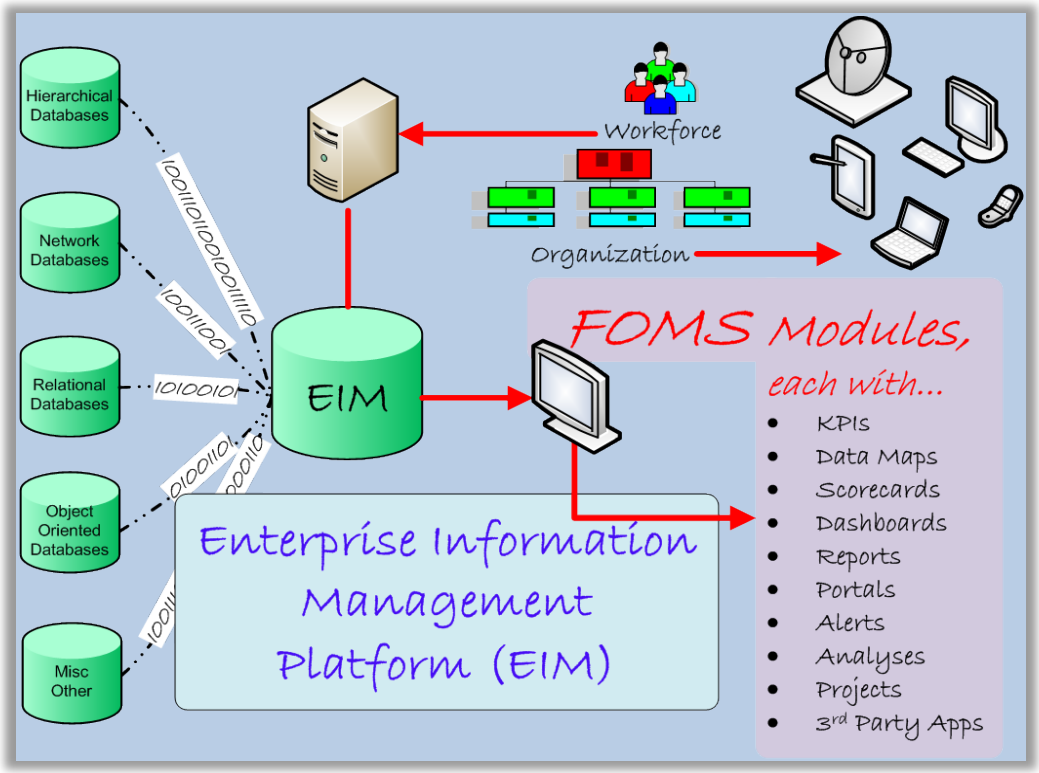
***KPIs are the critical life's blood of a properly designed management system in that they institutionalize processes and drive accountability, which in turn provides for continuity and sustainability.*** An effective KPI system and data mining process takes into consideration business drivers, success factors, targets, improvement actions, and performance measures. But knowing which metrics should be funneled into KPIs is the challenge.

Again, it would now seem that ***API 754 was written only to gauge the 'high level' effectiveness of PSM programs***. And yet, opportunity still remains for developing more in the way of focused metrics which further drive performance improvement in areas like flare and relief system design and operation, among others. And correspondingly, the CSB has characterized the shortcomings of API 754 as follows:

1. Tier 1 and 2 numbers are lagging indicators and thus of limited usefulness as performance indicators
2. Statistical power of likely small numbers of Tier 1 and 2 events is insufficient to detect effect
3. Tier 3 and 4 events are leading indicators which are reflective of process failures, and yet are not publicly reported and utilized for industry trend analysis and benchmarking comparisons
4. Employee participation was insufficient in the development process and thereby lacking in a broad-based consensus

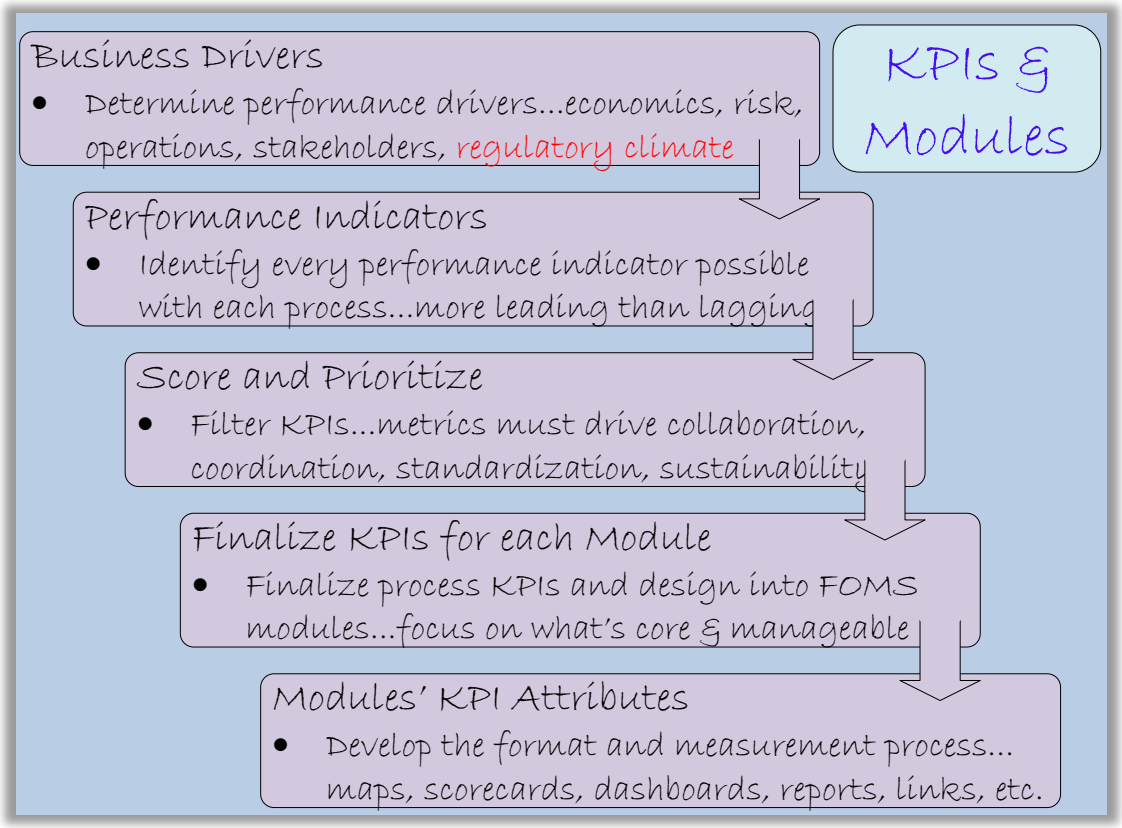
What I am suggesting is that we as an industry can be even more critical and innovative by utilizing historical operations, reliability and maintenance data in analytical tools and performance metrics to create a competitive environment for improving plant reliability and profitability. I stress the word 'competitive' in that this plan-do-check-act process will drive itself and grow by fostering a healthy and productive incentive among stakeholders for continuous improvement in reliability, profitability, and most importantly, process safety.

With KPIs, the idea is to tap into the data rich potential of an enterprise information management (EIM) system. And from this data and informational structure is extracted the 20% of data that 80% of operators, engineers, managers and execs want to see, with the challenge being identifying that 20% of key information. And beyond that, further consideration is necessary for the more refined development of KPIs which then provide the need-to-know requirements of stakeholders at a ***'dashboard' level of awareness.***



What so many KPIs fail to do is drill down deeply enough to facilitate the identification of basic and root causal factors associated with problem solving for optimal performance. And ***there can be too many of these focused metrics***, with the pitfalls being much the same as usability problems associated with multiple alarms annunciating during a process unit upset, commonly referred to as alarm flood. And just as with too many alarms, poorly designed alarms and improperly set alarm points, ***metrics flood and confusion*** can set in and negatively impact the problem solving process.

Proper development, implementation and management of metrics and KPIs should involve many of the same concepts utilized in alarm rationalization and management, and is really more of an art form than many realize. It requires critical thinking and strategic design aptitude which draws on frontline-to-exec level appreciation for what good looks like. And ***what good looks like*** is what the FOMS developers had in mind for a flare and relief systems focused management process.




Too often, the process of data gathering and metrics reporting is more about presentation than substance, and lacks real problem solving and process optimization potential. The metrics and KPIs of FOMS are specifically designed for problem solving performance improvement issues at the basic and root cause levels, and ***built around the business drivers of risk, regulatory, operations, and profits.***


## 5. The Profit Motive: Analyzing and Trending Performance

There is no doubt that profits are the motive behind all of business, and that includes the business of refining process safety. There are two primary objectives of most refining business strategies, and that is reducing costs and improving equipment reliability for optimum asset performance. And as such, ***process safety is a cost of doing business*** which involves a risk versus reward calculation, i.e., consequence versus likelihood of a process safety event.

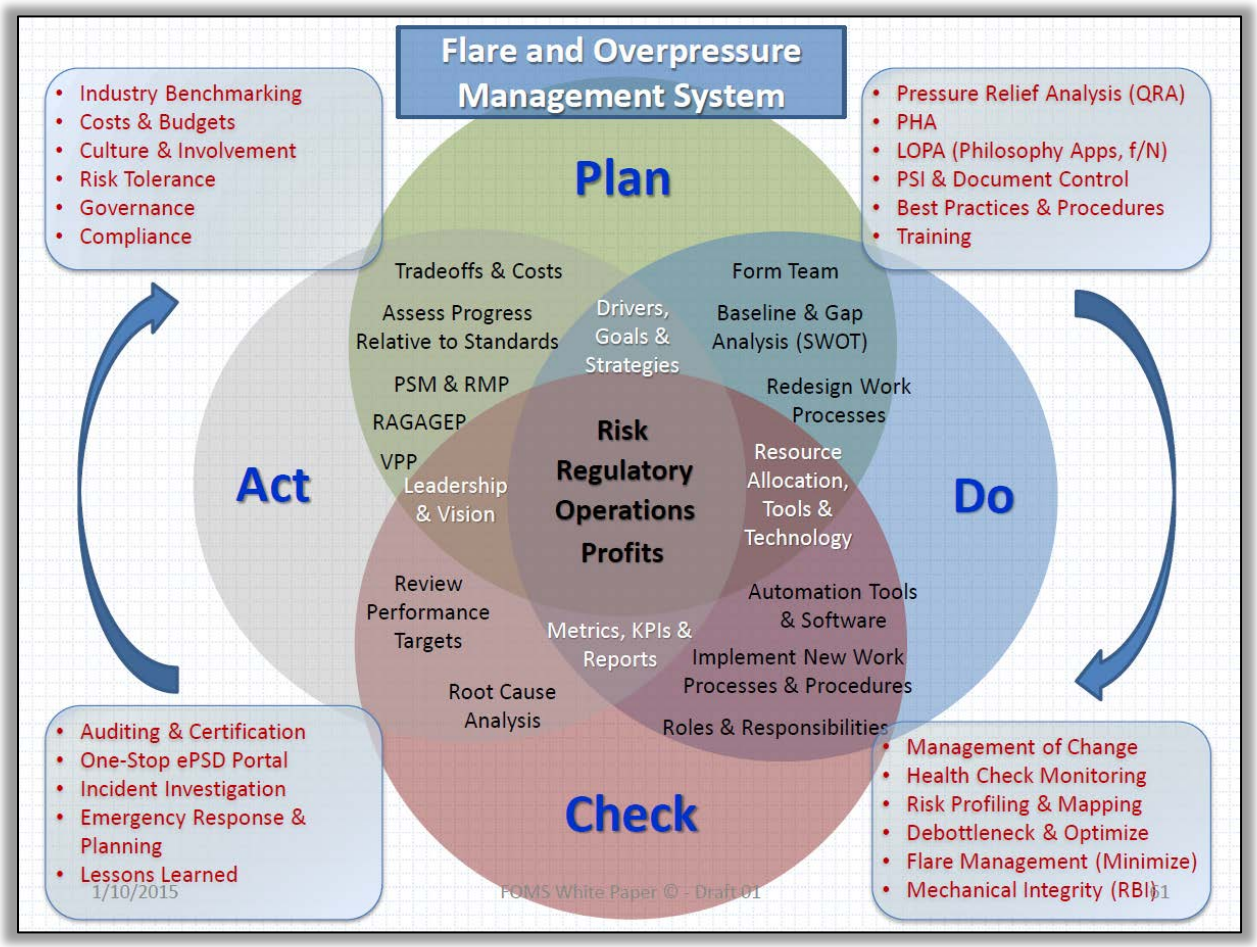
***Two key indicators used to evaluate manufacturing cost effectiveness are mechanical availability and maintenance costs as a percent of replacement asset value (RAV).*** It is widely accepted by manufacturing companies that world class manufacturing performance means operating at greater than 97% mechanical availability and spending less than 2 percent on maintenance as a percent of RAV.

Therefore, tools must be used to analyze and trend performance relative to those two measures, and employ various 'deep dive' methods and indicators which drive toward root causes of inadequate performance. To that end, I have developed a proprietary refining incident and loss database as well as process optimization methodology (via RCFA) which quantifies the economic impact ($'s lost profit opportunity LPO) of equipment anomalies, LOPC incidents and upset/malfunction operating conditions.

Such a RCFA approach is key to analyzing and trending cost minimization, driving process optimization and maximizing process safety performance in the refining industry.

## 6. Management System Design and Implementation

As previously mentioned, PSM was conceived out of a management system mentality of a plan-do-check-act cycle with continuous improvement at its core. The focused, metric-driven management system of FOMS follows this same model and function. And in application, it begins with a three phase development process: ***where are we now, where do we want to go,*** and ***how are we going to get there***.






***Phase I.*** **Where are we now?**

- Identify and engage process owners and stakeholders
  - A changing PSM and PRA landscape
  - BP, Tesoro, Chevron incidents driving reexamination of PSM rule
  - US refining accidents 3 to 4 times Europe
  - *Safety Case* and inherently safer design/technology (ISD) gaining favor with regulators
- Compile available documents and info
- Flowchart current processes, tasks and procedures
  - PRA methods and processes now mature
  - PRAs giving way to enhanced auditing, mini-PRA tune-ups and MOC processes

- Is more needed to insure PRA integrity?
- Intense regulatory scrutiny remains... ***risk, regulatory, operations*** and ***profit*** drivers

- Identify current tools and technology
  - PRA science and technology still evolving
  - Little in way of PRA specific management systems tools/IT
  - Lots of IT structure in need of management system content and integration
- Understand strengths, weaknesses, opportunities and threats in existing processes (SWOT analysis)

***Phase II.*** **Where do we want to go?**

- Engage process owners and stakeholders for vision, objectives and value drivers
  - Business focus (but not safety second)
  - Drive subject matter savvy to front-line
  - Team environment, but competitive
  - Systems thinking and problem solving
  - Communities of practice and pride
  - Knowledge managers, not tribal
  - Bottom-up, top-down...invert pyramid with 'closest to the work' mentality
  - Measurements, accountability and rewards
- Baseline processes and perform gap analysis
- Evaluate gaps and tradeoffs (costs)
- Redesign processes and functionalities
  - Think like an operator, manager, regulator
  - Metrics and reporting...KPIs
  - Ongoing gap analyses...data centric
  - Expert systems to automate
  - Integrate with existing...customizable
  - Process optimization and profits
  - Better manage and control change
  - Enable regulatory compliance…Safety Case?
  - Quality processes...TQM, SPC, Six Sigma
  - Cross-org integration and collaboration
  - Focus on operations workforce
  - Standardization and consistency
- Specify tool and technology needs
  - Workflows
  - Protocols and practices
  - Portals and links to data and systems
  - Data repositories
  - Search engines and links
  - Dashboards, scorecards, forums
  - Executive dashboards

- Document management
- Training and more training (CBTs)
- Enterprise discoverability and sharing
- Design to drive sustainability

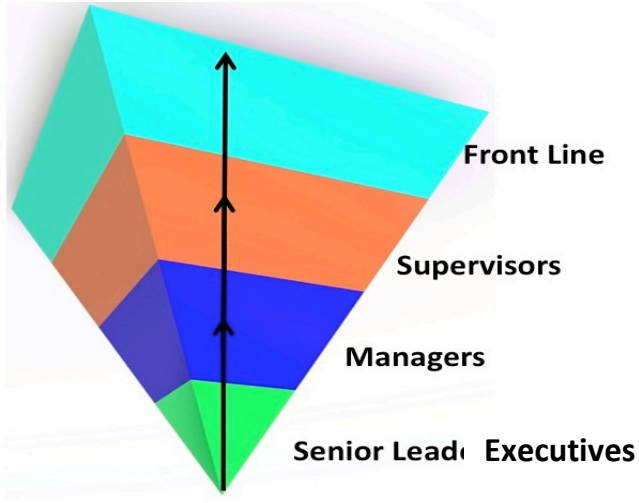
- Develop project plan and prioritize

***Phase III.*** **How are we going to get there?**

- Identify needs and objectives
- What good (or "where we want to go") looks like and how we plan a path forward
- Critical focus on management systems design and implementation: people, processes, tools/technology (including software solutions)
- Strategic focus on gaps, soft spots and critical systems within operations, maintenance and engineering organizations plus corporate
- Content…the 20% of data 80% of stakeholders want to see (strategic and customizable KPIs, data maps, scorecards, dashboards, reports, data portals, alerts, analyses, trends)
- ***Design to involve no new manpower, only new processes and tools***

- Develop strategic purpose
- Maintain a business perspective on everything, including process safety
- Tightly integrate strategy and tactics with business processes to be self-sustaining
- Ensure organization and systems are designed to enable execution of business processes
- Showcase new philosophy to inspire folks at all levels...from both bottom-up and top-down
- Design for employee involvement for buy in at all levels...again, make it competitive
- ***Integrate with existing assets, programs and systems***
- Get KPIs in hands of those closest to the work, i.e., those most able to affect change
- Connect enterprise performance measurement with budgets, reviews, and bonuses
- Make everyone an ambassador, including regulators...especially regulators
- Design metrics to be what operators, managers and executives want to see, i.e., KPIs
- Make adaptable to and compatible with outsourcing applications of IT and engineering services

- Establish team, leadership and governance…culture is very important
- Understanding and leveraging nuances of culture
- Plant environment (operations, maintenance, engineering, corporate)
- Cost/safety prioritization…RAGAGEP benchmarking
- Address internal competitiveness and silos
- Integrate with RBI and PSM offerings, leveraging IT and maximizing synergies
- Get regulators on-board…local and state OSHA, EPA
- Communicate to and involve all at all levels, and invert the hierarchical pyramid




- Perform root cause analysis
- Design metrics, KPIs, reports… automation tools
  - Design to drive sustainability (training, auditing, certification, profits)
  - Integrate with existing IT structure and software…synergies
  - Provide for enterprise discoverability and sharing
  - Leverage EIM platform, and integrate with:
    - Pressure relief analyses (PRAs)
    - Asset integrity management systems
    - Continuous emissions monitoring systems (CEMS)
    - PSM suite of software
    - Digital control systems
    - Process instrumentation
  - But, IT & software prowess need content in cohesive processes…FOMS
  - New/improved software solutions, business methods and internet innovations
- Initiate training programs
- Implement transition plan, pilot, then rollout
  - Compatible with 3rd party applications, software and systems
  - Leverage synergies/overlaps with PSM, equipment inspection and reliability programs (RBI API 580/581, especially damage mechanisms [API 572] and LOPC)
  - Flare/relief system specific programs for mechanical integrity, PHA, MOC, incident investigation, procedures, PSI, PSSR, and other PSM elements

***Phase IV.*** **How do we improve, grow and keep going?**

- Implement and validate redesigned process
- Initiate ongoing metrics and management system
- Monitor, evaluate and report on new processes
- Review targets and performance
- Audit and adjust for continuity, sustainability and growth

# FOMS

Business Case 01.vsd  Mtm 1/10/2015

**Key Business Impacts** → People ↔ Processes ↔ Tools/Technology

Continuous Improvement

## Where are we now?

### Pressure Relief Analysis (PRA)

- Changing PSM & PRA landscape
- BP, Tesoro, Chevron incidents driving reexamination of PSM rule
- US refining accidents 3 to 4 times Europe
- Safety Case & inherently safer design/ technology gaining favor with regulators
- PRA methods & processes now mature??
- PRAs giving way to enhanced auditing, mini-PRA tune-ups & MOC processes
- Is more needed to insure PRA integrity?
- Intense regulatory scrutiny remains… risk, regulatory, operations & profit drivers
- PRA science & technology still evolving
- Little in way of PRA specific management systems tools/IT
- Lots of IT structure in need of MS content & integration

## Where do we want to go?

- Refineries
- Oil platforms
- Chemical plants
- CNG/LNG facilities
- Pipelines & terminals
- Cogeneration plants
- Any PSM/process facility

### Management Systems Design & Implementation…like FOMS

- Business focus (but not safety second)
- Drive subject matter savvy to front-line
- Team environment, but competitive
- Systems thinking & problem solving
- Communities of practice & pride
- Knowledge managers, not tribal
- Bottom-up, top-down…invert pyramid with 'closest to the work' mentality
- Measurements, accountability & rewards
- Managers want management systems
- Regulators want management systems
- All this without adding to headcount
- Think like an operator, manager, regulator
- Metrics and reporting…KPIs
- Ongoing gap analyses…data centric
- Expert systems to automate
- Integrate with existing…customizable
- Process optimization & profits
- Better manage and control change
- Enable regulatory compliance…'safety case'
- Quality processes…TQM, SPC, six sigma
- Cross-org integration & collaboration
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- Dashboards, scorecards, forums
- Executive dashboards
- Document management
- Training & more training (CBTs)
- Enterprise discoverability & sharing
- Designed to drive sustainability

## How do we get there?

### Strategy & Tactics

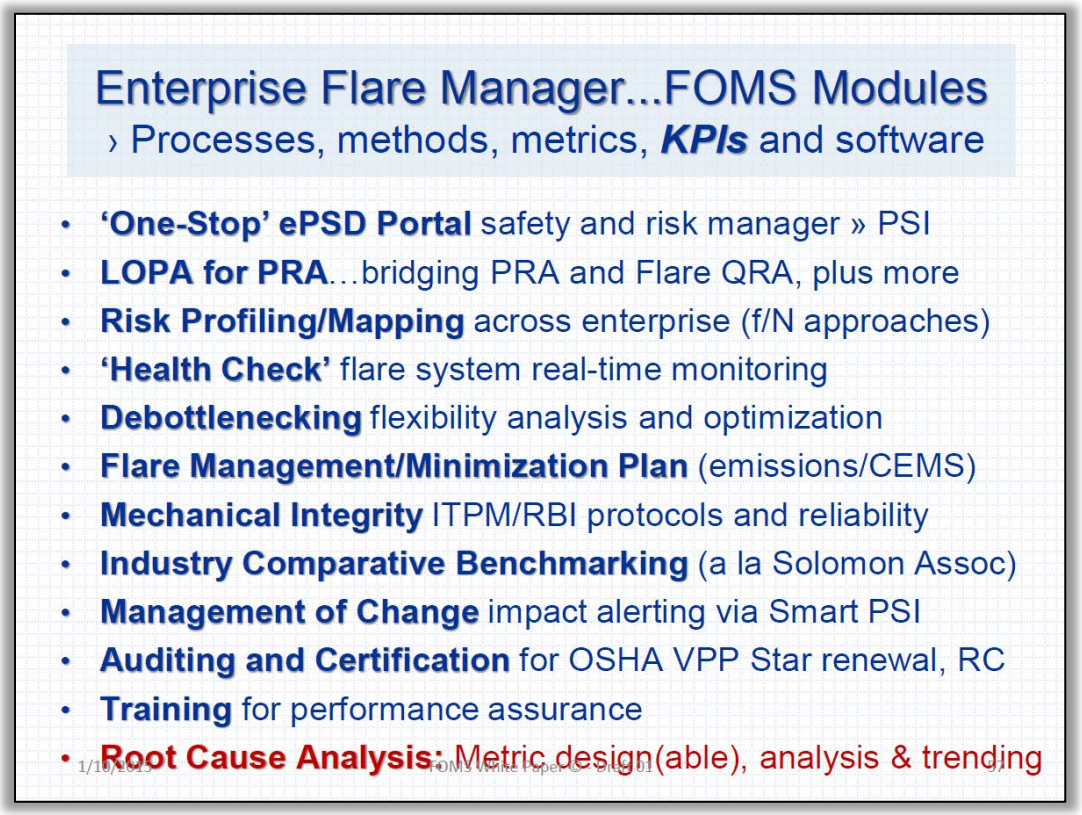
- Maintain a business perspective on everything, including process safety
- Tightly integrate strategy & tactics with business processes to be self-sustaining
- Ensure organization & systems are designed to enable execution of business processes
- Showcase new philosophy to inspire folks at all levels…from both bottom-up and top-down
- Design for employee involvement for buy in at all levels…make it competitive
- Get KPIs in hands of those closest to the work, i.e., those most able to affect change
- Connect enterprise performance measurement with budgets, reviews, & bonuses
- Conduct a white paper blitz within industry…make everyone an ambassador, including regulators…especially regulators
- Design metrics to be 20% of data 80% of operators, managers & executives want to see = KPIs
- Make adaptable to & compatible with outsourcing applications of IT & engineering services
- Pressure relief analyses (PRAs)
- Asset integrity management
- Continuous emissions monitors
- PSM suite of software
- EIM IT platform & synergies
- Digital control systems
- Process instrumentation
- But, IT & software prowess need content in cohesive processes
- New/improved software solutions, business methods & internet innovations

## How do we improve, grow & keep going?

### Other management systems…LOPC, reliability (RBI), process optimization, product quality, etc.

- LOPC most in need: Damage mechanisms (piping, vessels, mechanical equipment), design, procedures, unknown/other most prevalent causes…Tesoro & Chevron incidents in focus
- Strong regulatory drivers & business incentives
- Enterprise business processes
- Management system structure
- Management system philosophy & methods are transferable…cultural

## 7. Conclusion




In that a flare and relief system and associated safety systems are the last line of defense in overpressure protection, what better application is there for just such a strategic metrics-driven management systems initiative like FOMS. I will follow-up this paper with another entitled **A Flare and Overpressure Management System – Part II: Drilling Down into FOMS Enterprise Flare Manager Modules, Metrics and KPIs** which will further delineate the design and operation of the FOMS modules as well as discuss the application of associated metrics and KPIs.

## 8. A Close Second…

A close second to FOMS, however, would be a focused, metrics-driven management system approach addressing mechanisms contributing to the loss of primary containment (LOPC). The same people, processes and tools/technology (software and EIM) structure and methods employed in a flare and overpressure management system could be easily adapted for a LOPC focused initiative. And, this strategic initiative would involve the same business drivers of risk, regulatory, operations and profits.

What I am suggesting is that we as an industry can also be more critical and innovative in responding to LOPC incidents, data and metrics with enhancements to mechanical integrity proficiencies relative to inspection, maintenance, design and overall systems management. Historical operations, reliability and maintenance data can be better utilized and managed with analytical tools and performance metrics to determine needs, risk exposure, provide direction,

and address opportunistic reliability issues. This would certainly include a more critical focus on inherently challenging API 754 process safety event (PSE) LOPC metrics relative to damage mechanisms, operating envelopes, and consequences of deviation, procedures, design and training.

LOPC is preventable, and equipment reliability relative to process safety is by far the leading risk opportunity and ongoing business concern facing the Oil & Gas industry today. A LOPC focused metrics-driven management system would provide a more robust program for facilitating comprehensive process design and engineering relative to reliability improvement, i.e., ***'safety by design.'***

***I am currently writing a paper on the topic of LOPC and safety by design. The paper will also feature my proprietary refining incident and loss database as well as my process optimization methodology (via RCFA) which quantifies the economic impact ($'s lost profit opportunity LPO) of equipment anomalies, LOPC incidents and upset/malfunction operating conditions.***